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Soil-Transmitted Helminthic Infections: Updating the Global Picture

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Soil-transmitted helminth infections: updating the global picture

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Public health workers and parasitologists have long been interested in estimating numbers infected with particular parasite species. Recent changes in social and economic conditions as well as implementation of control in some regions of the world has changed the global picture of soil-transmitted helminth infections. This article brings global estimates up to date, reveals some interesting new trends, and discusses the future for control.

Teaser sentence: Urgently needed ppdated global estimates of prevalence and number of persons infected with Ascaris, Trichuris and hookworm by region and age group are presented and new relationships between hookworm and poverty revealed.

Ever since Norman Stoll [1] estimated the number of helminth infection in humans across the world in 1947, there have been regular endeavours to calculate and present global figures for soil-transmitted helminths (STH) [2-4], with the most recent estimates provided in 1994 by Chan *et al*. [5]. The sheer magnitude of these estimates has spurred international interest in these infections, and supported current global efforts in control [6]. Tremendous social and economic changes have also occurred throughout the world over the past few decades. In an effort to reflect these changes and bring the estimates of numbers up to date, here we provide an update on the global situation and look at trends in light of current approaches to parasite control.

Updated distributions and estimates

The work forms part of WHO's revision of disease burden estimates and uses the methodology developed by Chan *et al.* [5], building upon recent applications of geographical information systems to derive updated atlases of helminth infection [7-8]. To reflect recent changes in the epidemiology of infection, data were generally taken from only 1990 onwards wherever adequate data were available, although there are some exceptions (see Table 1 footnote). An extensive search of the literature, which included computerised searches, crossreferencing and personal networks, identified 494 publications with suitable data, from 112 countries (88% of countries included in the analysis). Only data from community-based surveys, with a sample size of >30, were included in the analysis [7]. Because of the vastness of their territory and population, prevalence rates in each Province/ Municipality/ Autonomous Region in China and in each State

/Union Territory in India were considered separately, in a manner equivalent to smaller individual countries. Together, these data represent a much larger database than those used in previous estimates*.

The updated global distribution of STH reveals some interesting features (Fig. 1). As in previous analyses [3-5] we found the tropics and subtropics to have widespread infection with all three STH. The highest rates of *Ascaris* infection occur in China and Southeast Asia, and in Africa in coastal regions of the West and in Central Africa. *Trichuris* infections reach their highest prevalence in Central Africa, Southern India, and Southeast Asia. Hookworm infections on the other hand, are common throughout much of Sub-Saharan Africa as well as in South China and Southeast Asia. Using the categorisation shown in Fig. 1, global estimates were derived of numbers infected in different age classes, and in different geographical regions (Table 1). These estimates indicate that ascariasis remains exceedingly common with over 1.2 billion infections globally. Almost half these infections are in China, which still has the highest prevalence. Trichuriasis and hookworm amount to about 700 – 800 million infections each. China and Sub-Saharan Africa have the largest number of cases of hookworm with about 200 million infections each. These numbers are largely derived from China's nationwide survey completed in the early part of the 1990s [9]. The hookworm prevalence in India was surprisingly low.

It is worth emphasising that these are aggregated estimates derived from all currently available data, and are not meant to reflect accurately fine-scale within-country variations in distribution, or necessarily to be representative of a given country as a whole. Thus, although the overall prevalence for a country appears low in Fig. 1, it may still have areas of high prevalence, which require control activities. For example, although the prevalence of hookworm infection in Mali is shown as < 25.0%, a prevalence of 44% has been recorded in some areas. This is also true in Brazil where, for example, the prevalence in Minas Gerais State frequently exceeds 50%. For reasons outlined previously [1,7], the estimates presented here, like the population figures on which they are based, are far from exact. A sensitivity analysis of the methodology used here found that the variability in estimated numbers infected is about 20% above and below the original estimated values [10].

Changes in the global situation

To explore changes in the global situation comparisons are made between the current estimates and those of 1994 (Fig. 2). In both the Americas and Asia, there appears to have been a marked decline in prevalence and in absolute numbers of all three infections since 1994. This decline actually reflects a change that has occurred over a period somewhat longer than a decade, because some of the prevalence data used for the 1994 estimates dated back to the 1960s. In several Asian and Latin American countries, there has been a dramatic decrease in prevalence rates, largely because of national control activities together with social and economic development [11,12]. For instance, in regions of rapid economic development and a shift from an agrarian to a suburban economy, such as in Jiangsu Province, China near Shanghai, the reduction in STH

* A complete bibliography and country-level results are available at (website).

infections was substantial [13]. Somewhat disappointing from a public health perspective, there appears to have been little change in prevalence rates in sub-Saharan Africa. This trend, paralleled by population increases, has lead to a dramatic increase in the absolute numbers of infections.

Burden of the poor

That the poorest people in the world suffer the greatest burden of infectious disease is beyond doubt [14,15]. Outside the developing world, the 20th century saw dramatic reductions in the prevalence of infection as a result of improvements in living standards and specific control programmes - Japan and Korea being the commonly cited examples [16,17]. In the developing world, inadequate water and sanitation and crowded living conditions, combined with lack of access to health care and low levels of education, make the poor particularly susceptible to infection and disease, including STHs. However, even within the developing world, wide differences in prevalence rates are also apparent. To investigate whether there are links between STH prevalence and poverty at the country level, we focused on hookworm. Figure 3 shows a striking relationship between the prevalence of hookworm and socio-economic status, as assessed by purchasing power adjusted average per capita incomes and Human Development Index, and indicates that the poorest countries have higher levels of hookworm than the least poor countries.

The connections between poverty and STH are complex, working in both directions. High STH prevalence may not have directly resulted in poor economic growth, but is clearly one of several contributing factors. Guyatt [18] has reviewed the studies that link STH infection and productivity in adults. Anaemia arising from STH infection is often associated with reduced work output and also impaired cognitive ability and effects on school attendance among children. In turn, the poor economic growth of some countries has meant continuing poor levels of sanitation and high prevalences of STH.

The future of control

Although it is not possible to claim that the figures presented here are definitive, they do provide an assessment of the current global situation. Such a perspective needs to be complemented by each country analysing its own infection patterns based on detailed and continually updated epidemiological evidence, essential for planning control. Where information is currently lacking, there is a need to identify further in-country data sources of information or conduct new surveys. Nonetheless, the number of infections can be used to give an idea of the global scale of the effort required to control STHs.

In terms of implementing control, the WHO urges member states to ensure access to good quality anthelminthic drugs at all levels of the health care system in endemic areas. Regular treatment of school-age children and other at-risk groups (such as pre-school children, pregnant women, and special occupation groups) will help to avoid the worst effects of infection even if there is no improvement in safe water supply or sanitation [6]. Treatment with any of the anthelminthic drugs on the WHO essential drugs list (albendazole, levamisole, mebendazole, or pyrantel) is safe, even when given to uninfected people, and thus there is no need for individual screening. The WHO recommendations on how frequently to deliver targeted treatment to high-risk groups in different endemic situations have recently been revised [19]. As a complementary approach to hookworm control, work is under way to develop a recombinant hookworm vaccine. The vaccine relies on a cocktail of recombinant larval and adult hookworm antigens, which reproduce some of the effects of live attenuated larval vaccines as well as vaccines that target parasite digestion and blood feeding [20]. Phase I trials to test the first recombinant larval antigen in humans are planned for 2004-05 (www.sabin.org).

The update presented here clearly indicates that STH infections must still be considered as the most prevalent infections of humankind. Although, in some regions, there has been a precipitous decline in STH prevalence primarily because of economic development and specific control, in many cases the prevalence rates are equivalent to those first estimated by Norman Stoll more than 50 years ago. The extraordinary numbers of STH infections, which approach two billion, are a reflection of a remarkably successful adaptation to parasitism by *Ascaris*, *Trichuris*, *Necator* and *Ancylostoma* nematodes. Short of dramatic improvements in the global economy, it appears unlikely that the prevalence of infection will decrease any time soon. However, despite this situation, the application on a large-scale of available simple and low cost interventions can significantly control the morbidity due to these infections in the vulnerable groups.

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Table 1. Global estimates of prevalence and the number of cases of intestinal nematodes by region and age group[a]

	Population (in millions)		Infection prevalence	Estimated number of infections (millions)				
				Age group				Total
	Total[b]	At risk[c]		0 – 4 y	5 – 9 y	10–14 y	> =15 y	
Ascariasis								
LAC	530	514	16%	8	10	10	56	84
SSA	683	571	25%	28	28	25	92	173
MENA	313	158	7%	3	3	3	14	23
SAS	363	338	27%	13	15	13	56	97
India	1,027	808	14%	15	18	17	89	140
EAP	564	560	36%	20	25	25	134	204
China	1,295	1,262	39%	35	44	51	371	501
Total	**4,775**	**4,211**	**26%**	**122**	**143**	**144**	**812**	**1,221**
Trichuriasis								
LAC	530	523	19%	10	12	12	66	100
SSA	683	516	24%	26	27	23	86	162
MENA	313	52	2%	1	1	1	4	7
SAS	363	188	20%	10	11	10	43	74
India	1,027	398	7%	8	9	9	47	73
EAP	564	533	28%	16	19	19	105	159
China	1,295	1,002	17%	15	19	22	163	220
Total	**4,775**	**3,212**	**17%**	**86**	**98**	**96**	**514**	**795**
Hookworm[d]								
LAC	530	346	10%	1	3	5	41	50
SSA	683	646	29%	9	18	29	142	198
MENA	313	73	3%	0	1	1	8	10
SAS	363	188	16%	2	5	8	44	59
India	1,027	534	7%	2	5	8	56	71
EAP	564	512	26%	4	9	16	120	149
China	1,295	897	16%	3	9	18	173	203
Total	**4,775**	**3,195**	**15%**	**21**	**50**	**85**	**584**	**740**

[a] Following the approach used by Chan *et al* [5] with subsequent modification by de Silva *et al* [10], these estimates are based on prevalence rates reported from 5 regions: Latin America and the Caribbean (LAC); Sub-Saharan Africa (SSA); Middle East and North Africa (MENA); South Asia (SAS); East Asia and the Pacific Islands (EAP). These regions correspond to those used by the World Bank. Only countries classified as 'low' 'lower middle' and 'upper middle' income economies, as defined in the World Development Indicators database (http://www.worldbank.org/data/wdi2002/), were included in the analysis. In Sub-Saharan Africa alone, because little control or improvement in sanitation has been undertaken, data were taken from 1970 onwards. For India, the Middle East & North African countries, Panama, Pakistan, Myanmar, Thailand and the Philippines, because of the paucity of representative data, the time period was extended to include the 1980's in addition to the 1990's. For Caribbean and Pacific Islands only, the average of prevalence rates in the other islands where surveys had been carried out, was extrapolated to those islands that had no prevalence data. Countries with reported prevalence rates of <5% were excluded from the analysis. This is because countries with such prevalence rates do not consider intestinal nematode infections to be of public health importance, and also because it was found that the model developed by Chan *et al.* [5] tended to over-estimate regional prevalence rates when dealing with very low national prevalence rates.

[b] Based on the 5th population census of China in 2000 (www.cpirc.org.cn/e5cendata2.htm); the population census of India in 2001 (www.censusindia.net); and population estimates for 2002 for all other countries [21].

[c] Population in areas with prevalence >5%.

[d] For *Ancylostoma duodenale* and *Necator americanus* combined.

Fig. 1. The global distribution of (a) *Ascaris lumbricoides*, (b) *Trichuris trichiura* and (c) hookworm. White areas represent countries not included in the present analysis.

Software (ArcView 3.3)

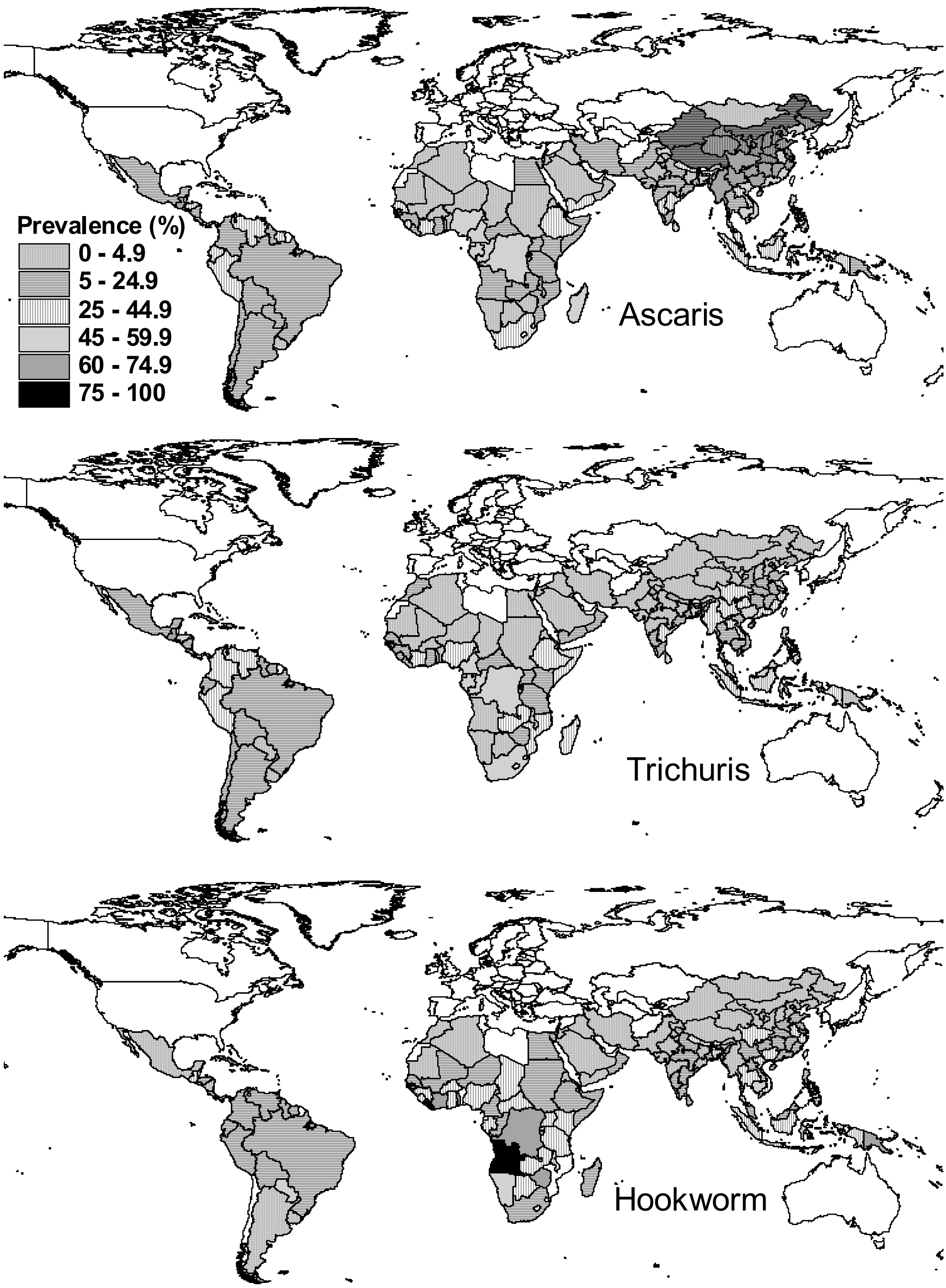
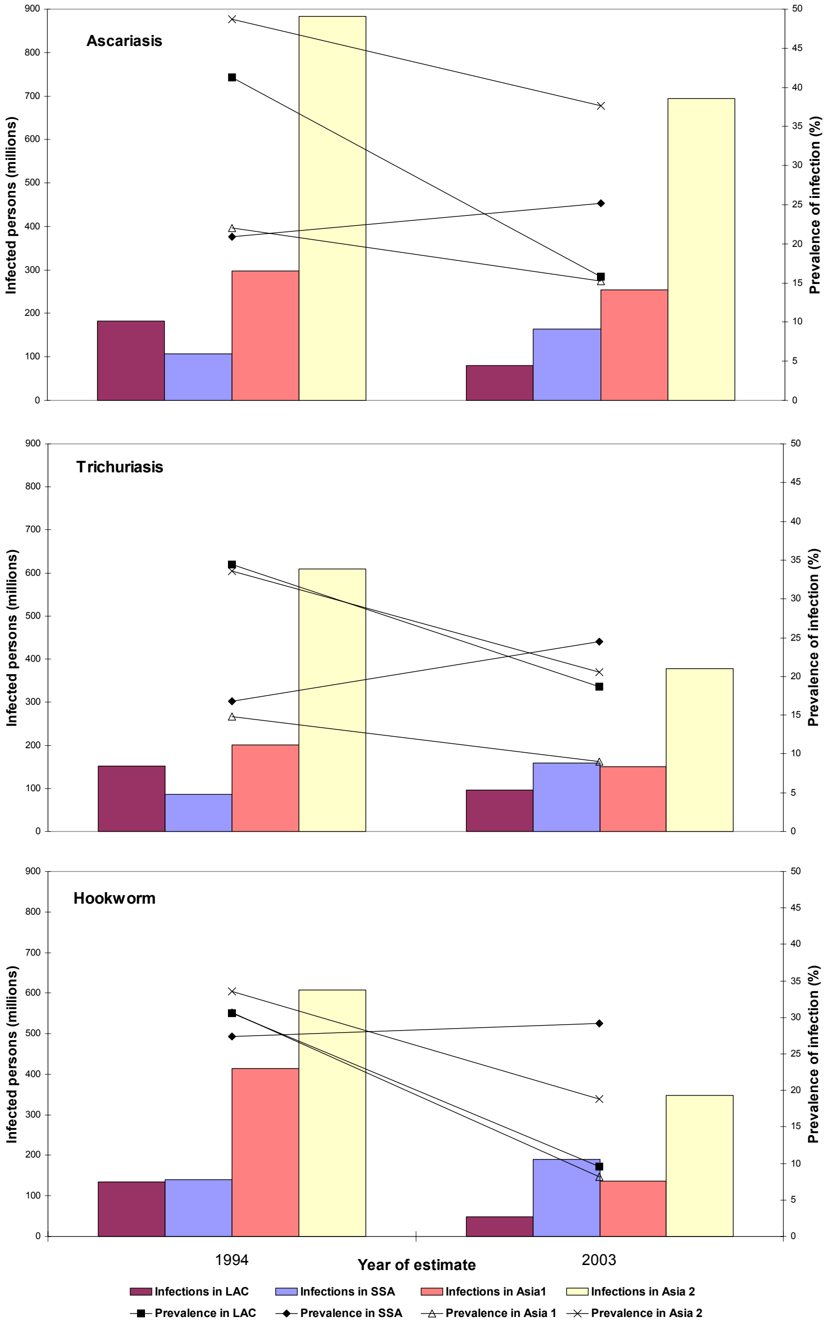


Fig. 2. Comparison of numbers of people infected and prevalence of ascariasis, trichuriasis and hookworm (*Ancylostoma duodenale* and *Necator americanus*) by region between 1994 and 2003[a].

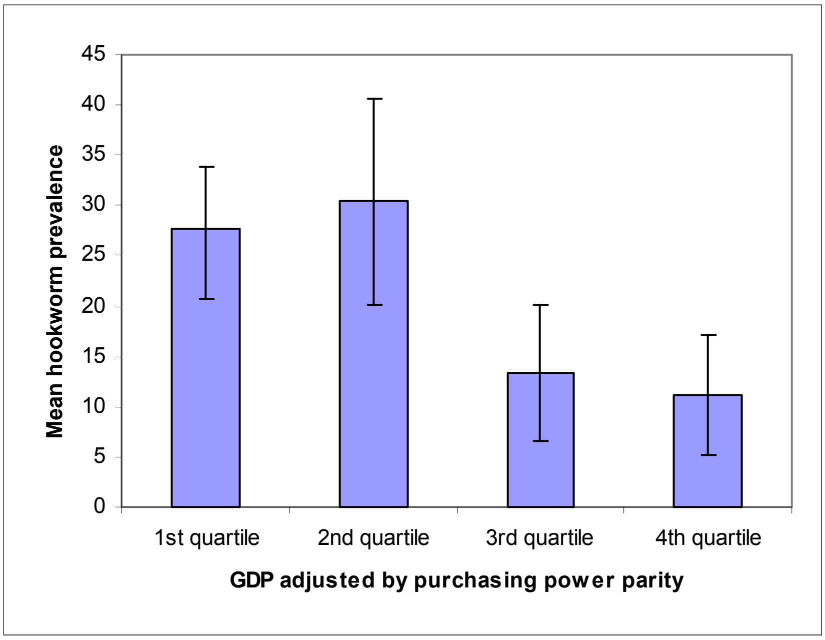
Software: Excel

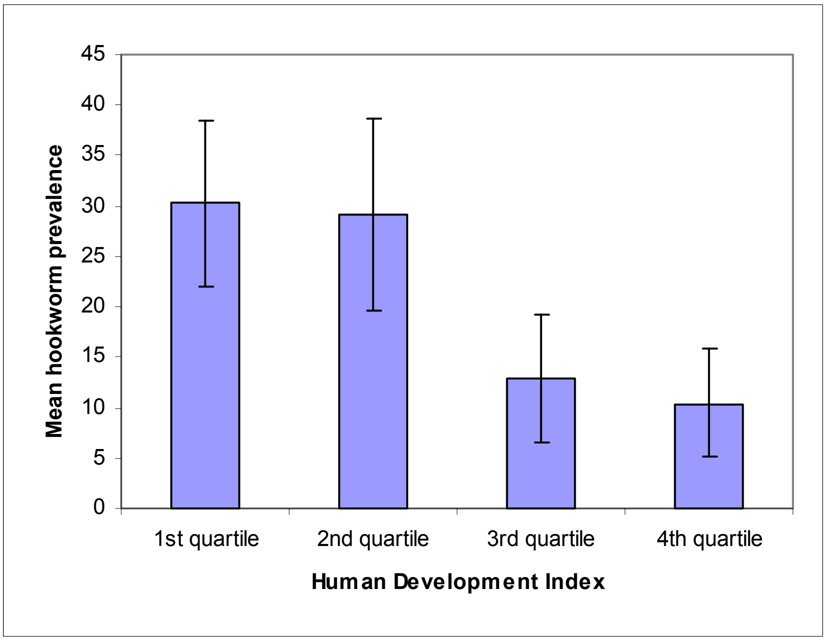


[a]LAC denotes Latin America and Caribbean; SSA denotes Sub-Saharan Africa; Asia 1 denotes Middle Eastern Crescent and India in 1994, and Middle East & North Africa, South Asia and India in 2003; Asia 2 denotes China and Other Asia and Islands in 1994; China and East Asia & Pacific in 2003. 1994 estimates from [5]

Fig. 3. The relationship between prevalence of hookworm and poverty[a].

Software: Excel





[a] Socio-economic status of 94 countries were assessed according to indicators as reported by the United Nation Population Programme (http://hdr.undp.org/statistics), including purchasing power parity adjusted gross domestic product per capita and Human Development Index (HDI). Country groupings were defined by dividing the poverty measures into quartiles, so that each country is divided into most poor, very poor, poor or least poor with a mean GDP of $1,467, $3,043, $5,880 and $15,073, and a mean HDI score of 0.478, 0.636, 0.747, 0.844, respectively. Error bars represent 95% confidence intervals. Trends are shown to be significant (p<0.001) as shown a F-test for heterogeneity.